Universal Quantum Gates for Two- and Three-Spin Qubits in Coupled Quantum Dots

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The ability to control the exchange coupling between coupled quantum dots allows for quantum gate operations on quantum dot spin qubits. Supplemented with single-spin rotations, the exchange coupling is universal for quantum computation on qubits that are formed by the spin 1/2 of single electrons. If qubits are formed by two spins, the requirement for single-spin rotations is reduced to the presence of a fixed inhomogeneous magnetic field, while for three spins, the exchange coupling is universal on its own. In this talk, we discuss the implementation of universal gate operations for two- and three-spin qubits in coupled quantum dots. In the case of the two-spin singlet-triplet qubit on a double quantum dot, we propose a set of universal gates that can be generated by controlling the electrostatic potential between the two dots without time-dependent control of the tunnel coupling between the dots [1]. This simplification should facilitate the implementation of quantum gates in the systems that are presently studied experimentally. We present explicit gate sequences for single-qubit rotations about two orthogonal axes, and a CNOT gate sequence, completing the universal gate set. Finally, the trade-off between leakage errors and simple operations will be briefly discussed.